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ABSTRACT

As an economical method of evaluating alternative building programs prior to deciding upon one, a computer-based mathematical model is described which could be used to simulate an institution's use of physical facilities. Information is presented regarding program input, measure of effectiveness, and program procedure. Sample forms and sample output are included. (FS)

ED037970

INFORMATION NEEDS:

for planning physical facilities in colleges and universities

Space Planning

November 1969

EF 004 162

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FOREWORD

This report is one in a series of four volumes which have been developed under a research project funded jointly by Educational Facilities Laboratories, Inc., and Duke University, in May of 1966. The three companion volumes are:[1]

Volume 1 — Overview

Volume 2 — Room Inventory: A Technique for Data Collection and Analysis

Volume 3 — Space-Demanding Activities: A Technique for Data Collection and Analysis

The first volume is devoted to an overview of the planning information needs of an institution of higher learning and an approach to the collection of appropriate activity and facility information. The purpose of the project has been to develop techniques which will assist institutions of higher education in dealing with the problems of physical facilities planning. In particular, projects the staff set out:

- To define a campus planning process
- To identify information useful in the planning process and show how it is most usefully organized
- To develop an economical method of testing the desirability of alternative building programs prior to deciding upon one.

This volume treats the last of these objectives by developing the structure of a computer-based mathematical model which could be used to simulate an institution's use of physical facilities.

I should like to thank several people who have contributed significantly to the development of this model. The original conceptual work was the product of Robert Holz, then of Hewes Holz & Willard of Winchester, Massachusetts, and now Director of the Computer Center, Western Washington State College. The concepts which he originally laid out are still largely intact. They have been modified by others; namely, Richard Willard, formerly of Hewes, Holz & Willard, and now the Senior Associate at the Center for Educational Software Development, New England School Development Council; Charles Sims, programming and systems consultant in Houston; and Stephan Van Pelt, systems analyst with CRS. These gentlemen contributed extensively to the further design and programming of the evaluator program. Philip Williams, Partner with Caudill Rowlett Scott, from the outset has been a valuable critic and advisor, providing much of the understanding of the problems in campus planning. Robert Mattox, formerly of CRS, and now President of Computing Research Systems Corporation (CRS2), has been responsible for the management of this particular phase of the project.

While we recognize that the programs presented in this volume are not complete in themselves, and do not provide a working package which can be implemented as a system at existing universities or colleges, we feel that we have achieved our original goal to demonstrate that manh data involved in campus planning can be quantified and related mathematically through such models as the one presented here. The

[1]Copies of these reports can be obtained from Educational Facilities Laboratories, 477 Madison Avenue, New York, New York 10022. Computer program listings and complete sample output are available through the EFL Library.

problems of planning future growth of campuses is a complex activity. Large volumes of data must be collected and assimilated effectively in order to achieve the best use of limited resources. We feel that the computer model presented here begins to treat this information in new ways, and we hope that some of the ideas presented here may eventually be used by others in developing more sophisticated and more readily implemented models.

Watler Matherly — Principal Investigator
November 1969

INTRODUCTION

The purpose of planning is to determine the most appropriate course of actions which will most nearly achieve a set of objectives with the resources available. It is assumed that the planning process is rational and consists of several steps. These steps are not always clearly defined due to overlaps of planning functions, feed back of information, reviews and possible repetition of earlier steps. Volume 1 of this series briefly treats the problems of planning and allocation of resources to user programs. "The institution may be viewed as an organism that depends for its survival upon the flow within it of information about

- Resources available for use by the system
- Options for action open to it in carrying out its aims
- Rules for use in deciding what actions to take and when.

"The requirements of an adaptive system seeking some definable ends are in general:

- That data on the rate of flow of resources and product be read by reasonably accurate sensors
- That the system be able to reference some set of prescriptive rules governing resource use
- That the system contain effective means of altering resource flows when adaption to the changing environment makes it necessary." [2]

Under the section on planning in the same volume (page 12) an approach to the campus planning process is diagrammed and ties together the characteristics described above. The model described here also considers the items of information mentioned above and the requirements of an adaptive system in terms of the campus. The model accepts data about resources available for use in the college. It displays some of the options for actions in carrying out its aims. The planner, the user of this model, must follow certain rules of the game in deciding which of the actions are most appropriate to be undertaken and at what points in time.

Because large quantities of data and many ramifications must be considered in most planning decisions, it is often desirable to study many alternatives before selecting one course of action. Computers can handle vast quantities of information swiftly and accurately and can enable the planner to investigate more alternative plans than current techniques permit. To be useful to the campus planner, evaluation techniques must provide information about the benefits, cost and timing implied in the actions specified by a plan. Design of a computer program which can handle all of these aspects is an overwhelming task; many of the data are not readily available; planning processes are varied and often not easily defined. The programs presented here, therefore, should be regarded as suggesting one structure, which might be pursued in constructing such a model. This study is meant to demonstrate that computers may soon be useful in many more ways that are now presently used in planning campus development.

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[2] Volume 1, page 3.

PROGRAM INPUT

This system of computer programs accepts data which describes the campus in terms of its activities and space relationships, simulates the growth of the activities over a specified period of time, and displays the effects achieved by the use of alternative actions to accommodate the growth.

Growing activities eventually produce pressures upon the space to which they are assigned and the administrator must act to alleviate such pressures. The institution can build new space, improve existing space, reassign space to other activities, or demolish space completely. Over a period of years there may be many alternate sets of such actions which the institution may take to alleviate pressures on facilities. The development of this system of programs has been directed toward finding that sequence of actions which enables the institution to employ its resources most effectively. The program is capable of bringing together information generated through fact finding, analysis, and projection of resources — functions performed earlier in the planning process.

As the program estimates quantities of activities for future time periods, pressures on space and conditions of the interactivity relationships are reported to the planner. A dialogue can take place between program and planner; the planner responds to the pressures described by the program by specifying which actions he considers appropriate to execute. Constraints having been placed upon these actions, the program simulates the execution of the actions and reports the resulting changes in use of institutional resources.

Various planning data are supplied as input to the evaluation program. This section outlines basic data requirements to describe institutional resources in terms of activities, space and money and defines certian terminology to be used in the model. The order in which these data are discussed is also the order in which they are supplied as input to the programs.

Number of plans: In this context a plan is a series of actions over a period of time which the planner defines as being one course to follow in the use of resources to accomplish stated aims. An objective of this model is to test alternative plans; therefore, multiple plans may be tested on any single run of the computer program. This input simply indicates how many plans will be evaluated in a given run.

Limits: These limitations indicate to the computer program how many sets of various data to expect. The limitations are placed upon numbers of cycles, activities, zones, projection rules, projects, affinity relationships, and space types.

Cycle: The unit of time for simulation is called a cycle. A cycle may be defined for the convenience of the institutional planner and most often will correspond to the budgeting period of one or two years.

Funds: For each planning cycle to be studied, capital funds available for construction are provided as input.

Density: The campus is zoned geographically, and each zone is numbered for identification. A zone may include one or more buildings and open area of the campus. A zone is an area which can

4 be considered for development of physical facilities or for outdoor activities, such as athletics, intramurals or parking. For each zone identified on campus, the maximum total space permitted to be constructed within that zone is provided as input. The amount of vacant (unassigned) space by space type in each zone is also input. Space types are identified in the sample problem as class, laboratory, office, study, special, general, support, housing, food and athletic.

Space Assignments: Space is assigned within each zone to activities. The assignment is made by space type and quantity of net area. A net-to-gross ratio permits that net area to be transformed to gross area assigned to that activity. The prime data for these space assignments should be the space inventory of the campus.

Interzone Distances: Distance, as used in this program may be distance measured in linear feet between centers of activities of geographic zones or travel time in minutes between the same centers of activities. The use of these distances will be explained later.

Interactivity Affinity: Affinity is the attraction or repulsion between one activity and another activity. The definition of activities must be appropriate to the institution being studied. In general, activities may range from lecture, laboratory and other regularly scheduled academic activities, to such activities as recreation, dining, eating and community activities. At this point, hard data on affinity relationship may be difficult to acquire. One source of academic inter-relationship can be obtained from the number of credit hours or clock hours of instruction provided by one activity to each of the other academic activities. Other values can be obtained by surveying the hours students, faculty and staff spend in various facilities, such as the library, student union and dormitories. Further investigation to define affinities could involve studies of interdepartmental research or joint use of various space types, or perhaps the department or administrative desires for one activity to be associated with another activity.

Projection Ratios: Projection ratios are patterns of growth anticipated for activities and are expressed as step functions. These ratios are the relationships of future quantities of activity to quantities at the present time and are specified as a device to simulate the growth of activities over a period of time. Projection ratios result from separate but necessary studies of probable growth rates of the activities considered. Their use as input to this evaluator program is but one of their applications.

Unit Costs: Unit costs per square foot for maintenance, renovation and new construction are entered for each cycle under investigation. These costs are entered for each space type. Later in the program maintenance costs for each existing space types are calculated. Spaces that are renovated are costed at the unit cost provided here; new space is estimated at the unit construction cost provided here. While at present there is no provision for considering escalation of these costs, such a factor would not be difficult to program.

Centralization: The details for calculating a measure of effectiveness for each plan will be discussed later. Several inputs to this measure will be described here. There are three contributors to the measure of effectiveness: *proximity, density*

and *utilization.* The input under the heading "Centralization" indicates the percent contribution which the proximity factors make to the total measure of effectiveness.

Central, Secondary and Remote: These factors relate to the "Density" contribution to the measure of effectiveness. The input values are the percent of the maximum density which will be considered ideal for zones which are classified as central, secondary or remote. The other item entered for each of these factors is the percent contribution of density to the measure of effectiveness.

Zone Type Designation: Each geographic zone which is identified in the model is classified as being central, secondary or remote. The ideal value for density of each of the three zone types is expressed as a percent of maximum allowable density for all zones of a class. The maximum allowable density for each zone is specified under "Density," above.

Utilization: This input is the percent of the maximum utilization, expressed under "Activities," which is considered to be ideal. For each activity minimum and maximum utilization are expressed; however, the factor expressed here is that value which is considered to be ideal. The other factor identified for utilization is the percent contribution that utilization will make to the measure of effectiveness.

Project: A project is defined as a set of actions involving specific activities, space and money in a particular time cycle. For a given project, time limits of the earliest and latest cycles for execution are given. The activities which are involved and for which actions are taken are specified. The actions will be taken if activities become critical. "Critical" indicates a condition or characteristic outside certain boundaries specified by the user. For instance, utilization of a specific activity may exceed the maximum specified for that activity or may diminish to a value less than the minimum specified. These conditions would be considered to be critical and the project would be executed. The number of actions involved in the project is also specified.

Action: A specific action involves an activity, a cost and space. Actions are defined as **add (A),** to subtract space from the vacant space available and assigning it to an activity; **build (B)** to create new space and add it to the campus inventory; **demolish (D)** to remove space from the inventory and to make it unavailable for assignment: **improve (I),** to maintain the current space, but improve it through adding new light fixtures, painting, carpeting, etc.; **subtract (S)** to unassign space from an activity and add it to the vacant space in the inventory. Since space is assigned by zone and activity, each of these factors must be specified in the action. The net square feet and the net to gross ratio are also expressed. Most actions will involve a cost, and this cost per square foot is specified as a part of the action. The **add** and **subtract** actions may simply reassign space and may not involve a cost.

MEASURE OF EFFECTIVENESS

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The "measure" suggested here is one indication of the total effectiveness of a plan in its use of institutional resources. It is this measure of effectiveness which the planner and administrator attempt to optimize through the execution of proper actions over time. The measure reflects the combination of weighted contributions from three parameters to determine success of a particular plan. These parameters are *proximity, utilization* and *density.*

Proximity: Proximity measures the assignment of space to activities in zones in order to satisfy interactivity affinity relationships most nearly. The objective is to assign space to activities such that the distances are minimum between activities having high affinity to one another. Conversely, those activities which have low or even negative affinity to one another shall be located as separate from one another as is practicable.

Strong affinity is defined as greater than or equal to .5, and activities having this relationship are to be located in the zones that are separated by a minimum interzone distance. Those activities which exhibit a weak affinity, which is defined as a value less than or equal to −.5, are to be located in zones separated by a maximum interzone distance. At any given time proximity is a measure of how nearly the distribution of the activity having affinities in the specified ranges approach an ideal value.

The ideal proximity value is defined as the sum of the cross products of all those activities having a strong affinity times the minimum interzone distance and the cross products of the activity levels of those activities having a weak affinity times the maximum interzone distance. In order to consider proximity as one variable, these two ideal values are averaged, giving the single value as the ideal.

The planner may then determine, relative to the particular configuration of zones for a given campus, how nearly such an ideal value might be realized. An arbitrary value of .7 is presently implemented in the program code. (If a user wishes to implement a different value, either arbitrarily or through experience gained in use of the program, it is a simple matter to change the statement in the program.)

Density: This factor measures the density levels within zones by zone type, comparing the existing density to the desired density. Desired density is expressed as a percent of maximum allowable density within a zone. Control of density should increase the measure of effectiveness. Considering density levels by zone type enhances the flexibility of the measure of effectiveness by permitting the planner to specify a given zone type as more sensitive to density consideration or crowding than another zone type. Zones may be specified as *central, secondary* or *remote,* but may be used to define zones by building density. For example, *central* could mean a zone in which it is desirable that there be a greater building density than in any other class of zones. *Secondary* might be taken to mean those zones in which it is more desirable to have sparse building density. *Remote* might be defined as those zones in which there is presently little (or it is deemed desirable that there be little) building density. In essence, there are simply three relative densities, one of which must be assigned to each zone. The density contribution to the overall measure of effectiveness is defined as a percent of realization of a predetermined ideal value which represents each of the three

zone types. The ideal density value for each of the three zones is expressed as a percent of maximum allowable density for all zones of a class.

Utilization: Utilization measures the quantities of activity as related to the space occupied by that activity. A criterion for determining the plan which is considered ideal is to have the space needs of each activity satisfied throughout the run. The degree to which the execution of projects satisfies these requirements is scored by the measure of effectiveness. Utilization contribution to the measure of effectiveness is defined as a percent of realization towards an ideal value for each activity, expressed as a percent of the maximum utilization throughout all zones. The range of permissible values for utilization for any given activity is 0 to 100% realization and is computed as 1.0 minus the deviation from the ideal value. Hence, an activity will not contribute in the measure if the utilization exceeds twice the ideal value. The utilization contribution to the measure is valid only for values up to 100% above the ideal value for a particular activity.

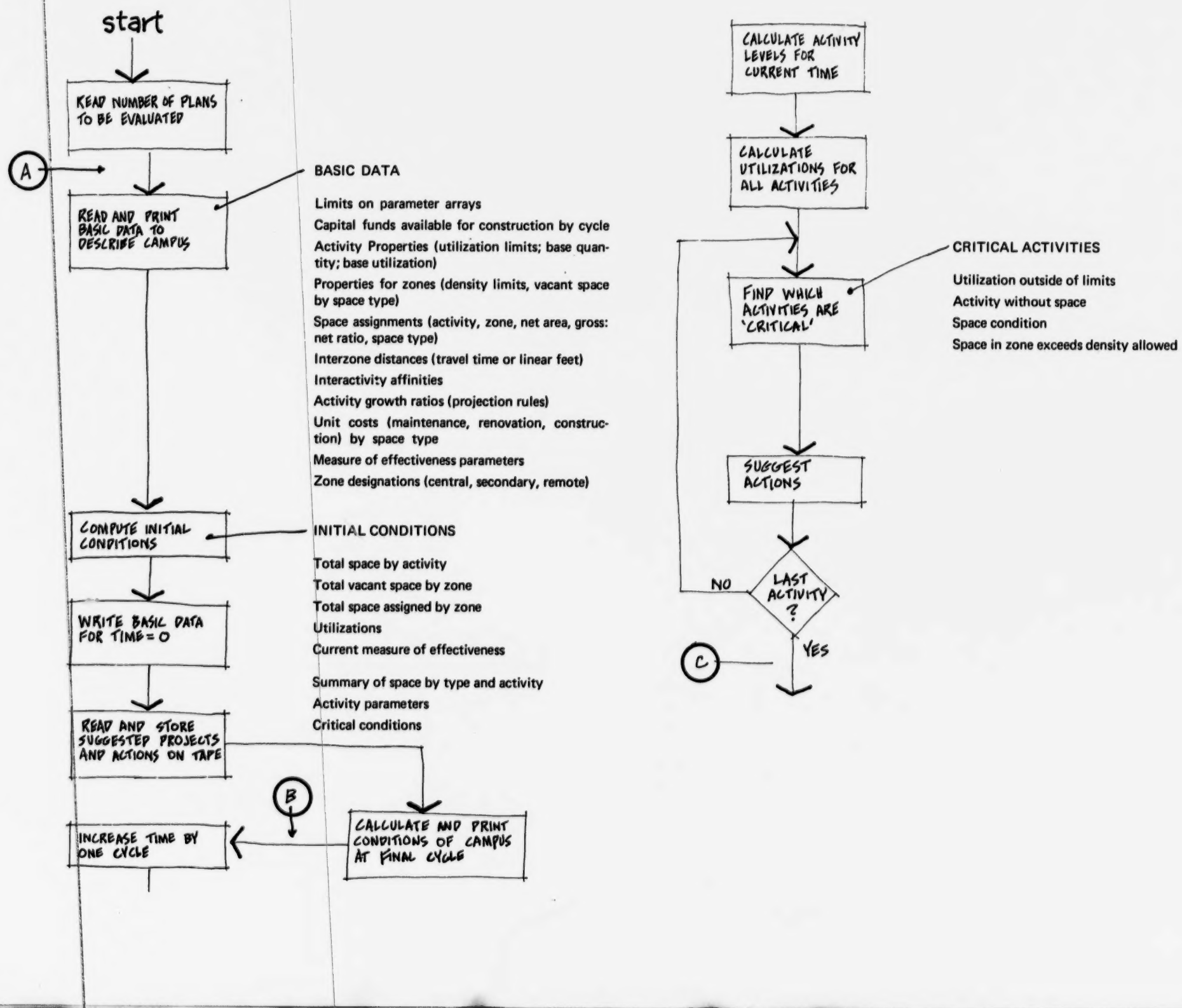
During program execution, the determination at any given time of the measure of effectiveness can be made from the parameters defined above by considering the present proximity relationships, density values by class, and percentage deviation from an ideal utilization value for each activity. The contribution towards a measure of effectiveness of each of these parameters is a weighted contribution as determined at input by three weighting factors. There is an advantage in having a measure which may be determined in this manner. The planner, by choosing appropriate values for each of the weighting factors, may determine the relative probability of any given plan achieving the ideal case for each of the criteria. It is important that the planner realize that the sum of weighting factors must be exactly 1.0.

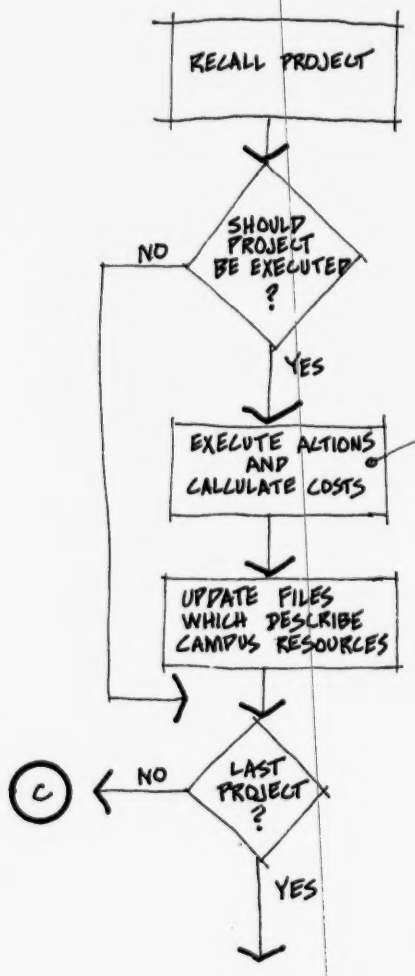
It is important that the sum of the factors not be less than 1, since each of the parameters by which a given factor is to be multiplied is a percent which may range from 0 to 100. It can be seen that selecting factors whose sum is greater than 1 would produce a measure of effectiveness greater than 100%, which would theoretically be impossible. If the sum of such factors were not identically one, the planner would be implying that no combination of weighting factors multiplied by the percent realization of the corresponding measure should equal 100% and that some parameter other than the ones used for grading (proximity, utilization and density) should be included in determining the score for the given plan. Therefore in the present program, the planner must insure that he achieves the best result possible based upon the criteria that are used and by insuring that the sum of weighting factors is one.

For each of the three parameters used as criteria in grading a plan, it is necessary to specify on a card input the data coefficient for the corresponding parameter. Additionally, for density and utilization parameters the percentages of ideal density or utilization. Ideal utilization is defined as a percent of maximum utilization. Ideal density is expressed as a percent of maximum density. The ideal proximity value is set internally at .7 and does not require the card input. There is a further requirement for the measure of effectiveness input in the case of

density; each zone on the campus is specified as being *central, secondary* or *remote.* These input required by the measure of effectiveness are set one time during the initialization for a run; they are a one-time requirement and are read in at the time that the data base for the campus plan are read in.

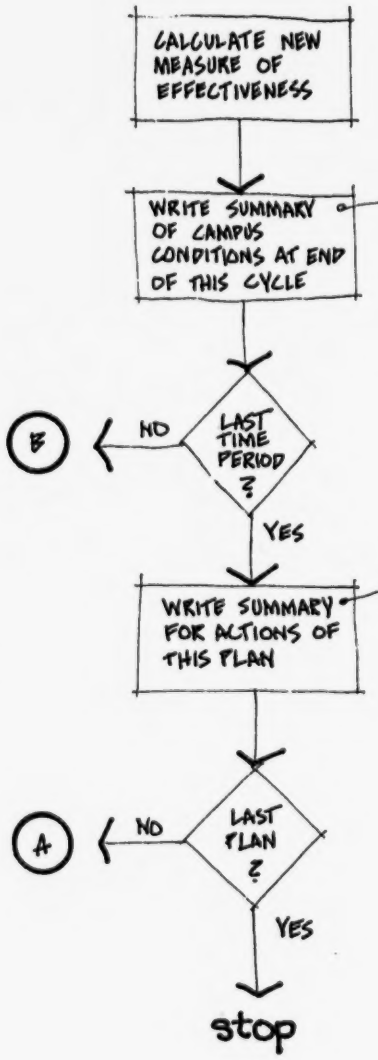
The computational techniques and program flow for the measure of effectiveness are discussed in Appendix 3.


start
READ NUMBER OF PLANS TO BE EVALUATED
A
READ AND PRINT BASIC DATA TO DESCRIBE CAMPUS
BASIC DATA
Limits on parameter arrays
Capital funds available for construction by cycle
Activity Properties (utilization limits; base quantity; base utilization)
Properties for zones (density limits, vacant space by space type)
Space assignments (activity, zone, net area, gross: net ratio, space type)
Interzone distances (travel time or linear feet)
Interactivity affinities
Activity growth ratios (projection rules)
Unit costs (maintenance, renovation, construction) by space type
Measure of effectiveness parameters
Zone designations (central, secondary, remote)
COMPUTE INITIAL CONDITIONS
INITIAL CONDITIONS
Total space by activity
Total vacant space by zone
Total space assigned by zone
Utilizations
Current measure of effectiveness
WRITE BASIC DATA FOR TIME = 0
READ AND STORE SUGGESTED PROJECTS AND ACTIONS ON TAPE
Summary of space by type and activity
Activity parameters
Critical conditions
B
INCREASE TIME BY ONE CYCLE
CALCULATE AND PRINT CONDITIONS OF CAMPUS AT FINAL CYCLE
CALCULATE ACTIVITY LEVELS FOR CURRENT TIME
CALCULATE UTILIZATIONS FOR ALL ACTIVITIES
FIND WHICH ACTIVITIES ARE 'CRITICAL'
CRITICAL ACTIVITIES
Utilization outside of limits
Activity without space
Space condition
Space in zone exceeds density allowed
SUGGEST ACTIONS
NO
LAST ACTIVITY ?
YES
C



POSSIBLE ACTIONS

Build space
Subtract space
Add space
Improve space
Demolish space



CYCLE SUMMARY

Measure of effectiveness
Capital expenditures and balance
Maintenance costs by space type
Current state of activity and zone properties

PLAN SUMMARY

Pattern of execution of projects
Funds spent for construction, maintenance, renovation
Measure of effectiveness

PROGRAM PROCEDURE

15/16

One of the objectives in the use of this program is to demonstrate the dialogue which is possible between planner and computer. It is not intended that any computer program can or should make decisions which are unrelated to the reality of the campus situation. The role of this computer program or others like it is to display the status of the campus activity-space-money relationships and the results or implications of taking various actions which the planner may propose in order to assist the decision making process. The approach has been to simulate the growth of activities through a given number of cycles. The growth of these activities produces pressures on the resources of space and money. The planner designs *projects,* consisting of various sets of *actions,* to alleviate these pressures. These projects are provided as data and together describe a *plan* of action. The program is run in order to simulate the execution of the actions and projects, to note the consumption of resources and the resulting effects on the measure of effectiveness.

If the actions taken in one sequence for a given plan do not completely satisfy the planner, he may design alternate plans consisting of different sets of projects. The objective of such sequential studies is to find which set of projects executed in which order produces the greatest increase in effectiveness per dollar expended.

SAMPLE OUTPUT

19/20

These comments refer to sample output which follows.

Space Assignments: Each activity is identified by an index number and a name such as humanities lecture, humanities lab, humanities officing and research, etc. The zone is identified by number within which the space is assigned. Each type of space assigned is identified by a code number and name, such as class (for classroom), general support, lab, special, office, etc. The net square feet assigned to that activity in that zone by space type is noted. In several instances, multiple entries for a space type within a zone to the same activity can be noted; this multiple assignment results from summarizing areas from different buildings within that same zone.

Summary of Total Space assigned to an activity by space type: From the many space assignments to activities noted above, a summary table is generated showing for each activity the total space assigned to that activity by space types, such as classroom, lab, office, study, etc.

Interzoned distances: The numbers beneath the titles "OF" and "TO" indicate the distances *from* a zone *to* each of the other zones. In the first column, the distance from zone 1 to zone 2 is 538 units. The units in this case were taken as straight line linear feet. The intrazone distance it will be noted is always 1. An average walking distance within that zone could be entered instead. The distance from zone 1 to zone 11 is 2,366 feet.

Interactivity affinities: The values suggested here lie between 0 and 1. The affinity between an activity and itself is 1.

In the example, the affinity between activity 1 and activity 16 is .10.

Growth ratios by cycles: These ratios are input data and are listed here for verification. The ratios shown for each cycle are the growth anticipated in relation to the base data at time zero. Thus, humanities lecture is expected to be 10% greater in cycle 1 than at base time, 35% greater in cycle 2, and 65% greater in cycle 3.

Utilization report: For each activity the minimum and maximum utilization limits are listed, together with the current activity level and the current utilization. The total area assigned to the activity is also listed. As base input the currect utilization is given; using that basic utilization, a relationship is established between activity and total area which is used thereafter to calculate the current utilization.

Square feet assigned by space type within zone: For each zone the area assigned to all activities is summarized by space type. A zone total is given as is the maximum area permitted within that zone.

Square feet of vacant space by type within zone: For each zone the area which is vacant or unassigned to an activity is noted by kind of space. A total is given for each zone, which summarizes all kinds of space types.

Measure of Effectiveness for a Plan and a Cycle of Investigation: The measure of effectiveness in this example is 59.15. At this point, the measure reflects the initial status of campus. It is this

measure that we wish to improve through the use of our resources simulated to the execution of projects.

Plan 1, Cycle 1

For this cycle, the funds available for contruction are $10,000,000. The activities are noted by name and the level of activity. In this case Humanities Lecture is represented by 20,209 clock hours of instruction.

Critical activities (utilization): Each activity for which the current utilization lies outside the bounds of maximum or minimum utilization, the following factors are listed: activity identified by code and name, current utilization, maximum utilization, minimum utilization, a priority index, an area for minimum utilization and an area for maximum utilization.

The priority index is a composite number representing 1) the degree to which the current utilization lies outside the bounds specified by the planner and 2) the amount of activity involved. Therefore, if two activities exceed the maximum utilization by the same degree, the activity with the greater amount of activity would rank higher in priority for attention than would the other activity. Areas are calculated and displayed which would be required to bring the utilization to a minimum or to a maximum level for that activity. The project to be described or suggested for that activity probably lies somewhere between these two areas.

Critical Activities (No Space): Activities would be listed in this section during some cycle in which a new activity was created but for which no space was provided.

Critical Activities (Space Condition): If the space assigned to activities is linked to the current space inventory of the institution, space condition could be reported and could cause an activity to become critical. This condition could indicate the need for renovation or demolition of that space. The activities involved are indicated.

Critical Zones: (Density) A maximum allowable area for each zone has been provided as input. When the current area assigned in that zone exceeds the allowable area, the zone is said to be critical. The information displayed is the zone identification the current area in that zone, the area allowable for that zone, the excess and the activities in the area assigned to those activities which reside in that zone. From this information, if space is to be demolished, those activities which are likely to be effected are known.

Projects

A project is comprised of a set of actions. The actions available to the planner are: to *add* space, which indicates the assignment of space to activities; to *build* space, which means creating new space on the campus; to *demolish* space, which means removing space from the inventory; to *subtract* space or unassign space from an activity; or to *improve* space by means of renovation. A set of these actions comprises a project. Additional constraints on the execution of the project are 1) the earliest and latest cycles within which the project may be executed and 2)

the availability of capital funds for such actions. In the first example in the sample output, Plan 1, Cycle 1, Project 1, the earliest cycle is cycle 1 and the latest cycle is cycle 4, in which the project could be executed. The cycle is critical and one of the activities listed is also critical. We see that activity 15 "Residential" in zone 57, a quantity of 19,287 square feet was to be destroyed for a lump sum of $12,500. The utilization after that action, which removed space from the assignment to residential activities, has been recalculated at 1.036. Similar actions are executed within that project. Project 2, Cycle 1, is not critical. Other projects are shown in the sample. Following the execution of these projects, which have affected density, proximity and utilization, the new measure of effectiveness is shown to be 63.66, an improvement over the original measure of 59.15. A summary for Cycle 1 is shown. Funds available, the costs of that cycle and the remaining balance are indicated. Maintenance costs for Cycle 1 for each space type show the quantity of that space type and the unit cost for maintaining that kind of space. Total costs of the space type and for the institution are shown. The summary continues to show the activities which remain critical, by reason of utilization, no space condition, or critical zones.

The plan continues with activities growth being simulated through each cycle and projects being executed as appropriate when activities are critical and funds are available. At a completion of the simulation of a plan, a summary of the condition of this institution at that point is given. The first aspect of the summary is to show in which cycle each project was executed. In the sample, Projects 1, 3, and 5 are executed in Cycle 1, Projects 3 and 4 in Cycle 2, and no projects in Cycle 3. Reports in the same format as the base data are provided, showing the utilization levels for each activity, the area assigned by space type to zones, the unassigned space to zone by space type, and the measure of effectiveness at the end of the plan. Additionally critical activities and zones are displayed. A summary of construction costs, renovation costs and maintenance costs are shown as the final output.

EVALUATION STUDY FOR PROPOSED CAMPUS PLANS
A PROJECT SPONSORED BY EDUCATIONAL FACILITIES LABORATORIES, DUKE UNIVERSITY, AND CAUDILL ROWLETT SCOTT

INITIAL DATA FOR PLAN 1

CYCLE	CAPITAL FUNDS
1	10000000.
2	15000000.
3	20000000.

SPACE ASSIGNMENTS

	ACTIVITY	ZONE		SPACE TYPE	NET SQUARE FEET
1	HUM LECT	7	1	CLASS	1178.
1	HUM LECT	19	1	CLASS	420.
1	HUM LECT	19	1	CLASS	1576.
1	HUM LECT	19	1	CLASS	4344.
1	HUM LECT	19	1	CLASS	391.
1	HUM LECT	19	1	CLASS	680.
1	HUM LECT	19	1	CLASS	1002.
1	HUM LECT	19	1	CLASS	3368.
1	HUM LECT	19	1	CLASS	1415.
1	HUM LECT	19	1	CLASS	45.
1	HUM LECT	19	6	GENERAL	312.
1	HUM LECT	19	6	GENERAL	1751.
1	HUM LECT	19	7	SUPPORT	760.
1	HUM LECT	19	7	SUPPORT	40.
1	HUM LECT	19	7	SUPPORT	48.
1	HUM LECT	19	7	SUPPORT	106.
1	HUM LECT	19	7	SUPPORT	83.
1	HUM LECT	23	6	GENERAL	183.
1	HUM LECT	30	1	CLASS	1873.
1	HUM LECT	31	1	CLASS	3441.
1	HUM LECT	31	1	CLASS	2397.
1	HUM LECT	47	1	CLASS	2163.
1	HUM LECT	47	1	CLASS	1275.
1	HUM LECT	47	1	CLASS	1621.
1	HUM LECT	47	1	CLASS	94.
1	HUM LECT	47	6	GENERAL	389.
1	HUM LECT	47	6	GENERAL	4559.
1	HUM LECT	47	7	SUPPORT	1053.
1	HUM LECT	47	7	SUPPORT	168.
1	HUM LECT	47	7	SUPPORT	360.
1	HUM LECT	52	1	CLASS	1714.
1	HUM LECT	52	1	CLASS	1512.
1	HUM LECT	52	1	CLASS	346.
1	HUM LECT	52	6	GENERAL	437.
1	HUM LECT	53	1	CLASS	1523.
1	HUM LECT	53	1	CLASS	1741.
1	HUM LECT	53	1	CLASS	452.
1	HUM LECT	53	1	CLASS	1238.
1	HUM LECT	53	1	CLASS	2450.
1	HUM LECT	53	1	CLASS	38.
1	HUM LECT	53	7	SUPPORT	14.
1	HUM LECT	59	6	GENERAL	1744.
2	HUM LAB	7	2	LAB	11079.
2	HUM LAB	19	2	LAB	1694.
2	HUM LAB	19	5	SPECIAL	133.
2	HUM LAB	19	5	SPECIAL	1966.
2	HUM LAB	19	5	SPECIAL	553.
2	HUM LAB	47	2	LAB	451.
2	HUM LAB	47	2	LAB	5739.
2	HUM LAB	47	2	LAB	598.
2	HUM LAB	47	2	LAB	1884.
2	HUM LAB	47	2	LAB	376.
2	HUM LAB	53	2	LAB	837.
2	HUM LAB	53	2	LAB	1265.
2	HUM LAB	55	2	LAB	8694.
3	HUM O/R	7	3	OFFICE	5801.

SUMMARY OF TOTAL SPACE ASSIGNED TO AN ACTIVITY BY SPACE TYPE

	ACTIVITY	CLASS	LAB	OFFICE	STUDY	SPECIAL	GENERAL	SUPPORT	HOUSING	FOOD	ATHLETIC	TOTAL
1	HUM LECT	38299.	0.	0.	0.	0.	9375.	2652.	0.	0.	0.	50326.
2	HUM LAB	0.	30617.	0.	0.	2652.	0.	0.	0.	0.	0.	33269.
3	HUM O/R	0.	0.	51053.	0.	545.	466.	0.	0.	0.	0.	52064.
4	S S LCT	31876.	0.	0.	0.	0.	7563.	12207.	0.	0.	0.	51646.
5	S S LAB	0.	19250.	0.	0.	0.	0.	0.	0.	0.	0.	19250.
6	S S O/R	0.	0.	49161.	0.	2435.	0.	0.	0.	0.	0.	51596.
7	SCI LCT	21059.	0.	0.	0.	0.	5008.	23901.	0.	0.	0.	49968.
8	SCI LAB	0.	139457.	0.	0.	0.	0.	0.	0.	0.	0.	139457.
9	SCI RSCH	0.	625.	0.	0.	1758.	0.	2184.	0.	0.	0.	4567.
10	SCI OFF	0.	0.	45692.	0.	0.	0.	1407.	0.	0.	0.	47099.
11	ENG LCT	4130.	0.	0.	0.	0.	0.	3419.	0.	0.	0.	7549.
12	ENG LAB	0.	22658.	0.	0.	0.	0.	0.	0.	0.	0.	22658.
13	ENG RSCH	0.	0.	0.	0.	255.	0.	0.	0.	0.	0.	255.
14	ENG OFF	0.	0.	9313.	0.	0.	0.	0.	0.	0.	0.	9313.
15	RESDENTL	0.	0.	12388.	1898.	0.	29349.	16414.	408419.	84303.	0.	552771.
16	STUDY	0.	0.	0.	69746.	0.	0.	0.	0.	0.	0.	69746.
17	RECRTN I	4670.	0.	9050.	328.	0.	1072.	3527.	1215.	0.	58802.	78664.
18	RECRTN O	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	GEN ADMN	6109.	0.	87625.	1616.	5039.	45754.	79146.	181.	3292.	39927.	268689.
20	AUXLRY	0.	37.	16600.	2888.	0.	2038.	3799.	17403.	2482.	0.	45247.
21	PUBLIC	0.	0.	18446.	137.	0.	5021.	0.	0.	0.	0.	23604.
	TOTALS	106143.	212644.	299328.	76613.	12684.	105646.	148656.	427218.	90077.	98729.	1577738.

INTERZONE DISTANCES

FROM	TO	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
1	1	1,00	538,00	1077,00	1543,00	2130,00	2126,00	1720,00	999,00	783,00	559,00
1	11	2366,00	1589,00	1449,00	1822,00	2446,00	2810,00	2710,00	3167,00	2893,00	2425,00
1	21	2031,00	1758,00	2121,00	2075,00	2358,00	2356,00	2593,00	2675,00	2858,00	3083,00
1	31	3214,00	3383,00	2617,00	3467,00	3991,00	4401,00	4902,00	5826,00	6831,00	7600,00
1	41	8403,00	8831,00	9058,00	9231,00	9360,00	9502,00	9897,00	9669,00	9663,00	9465,00
1	51	9489,00	9914,00	10031,00	10120,00	10373,00	10696,00	10581,00	10435,00	10250,00	10159,00
1	61	3747,00	3041,00	3504,00	3473,00	4005,00	4885,00	5124,00	5125,00		

FROM	TO	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
2	1	538,00	1,00	538,00	1006,00	1601,00	1664,00	1300,00	650,00	614,00	807,00
2	11	2573,00	1655,00	1206,00	1475,00	2113,00	2372,00	2311,00	2809,00	2581,00	2152,00
2	21	1775,00	1583,00	2185,00	1947,00	2261,00	2174,00	2350,00	2530,00	2664,00	2826,00
2	31	2921,00	3059,00	2529,00	3359,00	3901,00	4242,00	4713,00	5635,00	6628,00	7410,00
2	41	8203,00	8666,00	8787,00	8967,00	9018,00	9140,00	9535,00	9334,00	9344,00	9163,00
2	51	9234,00	9615,00	9715,00	9788,00	10028,00	10357,00	10253,00	10125,00	9955,00	9892,00
2	61	3375,00	2549,00	3030,00	3042,00	3558,00	4438,00	4691,00	4655,00		

FROM	TO	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
3	1	1077,00	538,00	1,00	471,00	1081,00	1264,00	1000,00	654,00	850,00	1253,00
3	11	2868,00	1880,00	1179,00	1270,00	1677,00	1984,00	1981,00	2515,00	2352,00	1990,00
3	21	1660,00	1562,00	2373,00	1963,00	2289,00	2117,00	2213,00	2495,00	2569,00	2655,00
3	31	2704,00	2801,00	2555,00	3335,00	3883,00	4146,00	4579,00	5491,00	6463,00	7256,00
3	41	8035,00	8552,00	8542,00	8604,00	8695,00	8795,00	9190,00	9018,00	9047,00	8884,00
3	51	9005,00	9337,00	9420,00	9474,00	9701,00	10035,00	9943,00	9835,00	9681,00	9646,00
3	61	3054,00	2080,00	2581,00	2651,00	3141,00	4014,00	4283,00	4201,00		

FROM	TO	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
4	1	1543,00	1006,00	471,00	1,00	618,00	950,00	850,00	897,00	1179,00	1656,00
4	11	3115,00	2104,00	1270,00	1179,00	1700,00	1644,00	1700,00	2253,00	2158,00	1878,00
4	21	1615,00	1646,00	2546,00	2015,00	2334,00	2095,00	2113,00	2476,00	2494,00	2506,00
4	31	2510,00	2567,00	2586,00	3301,00	3845,00	4038,00	4430,00	5323,00	6272,00	7070,00
4	41	7834,00	8360,00	8276,00	8290,00	8364,00	8446,00	8841,00	8693,00	8736,00	8589,00
4	51	8750,00	9042,00	9111,00	9150,00	9366,00	9703,00	9621,00	9529,00	9388,00	9378,00
4	61	2755,00	1656,00	2169,00	2291,00	2753,00	3614,00	3895,00	3777,00		

FROM	TO	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
5	1	2130,00	1601,00	1081,00	618,00	1,00	656,00	877,00	1323,00	1637,00	2160,00
5	11	3384,00	2383,00	1480,00	1185,00	1495,00	1187,00	1337,00	1882,00	1891,00	1750,00
5	21	1608,00	1713,00	2743,00	2091,00	2379,00	2070,00	1981,00	2429,00	2371,00	2281,00
5	31	2225,00	2221,00	2601,00	3202,00	3725,00	3820,00	4152,00	5013,00	5924,00	6725,00
5	41	7467,00	8025,00	7829,00	7791,00	7846,00	7909,00	8303,00	8181,00	8238,00	8109,00
5	51	8316,00	8561,00	8614,00	8637,00	8841,00	9181,00	9111,00	9035,00	8910,00	8926,00
5	61	2313,00	1068,00	1589,00	1779,00	2195,00	3037,00	3328,00	3176,00		

FROM	TO	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
6	1	2126,00	1664,00	1264,00	950,00	656,00	1,00	447,00	1152,00	1450,00	1983,00
6	11	2885,00	1927,00	1044,00	626,00	840,00	719,00	751,00	1305,00	1253,00	1096,00
6	21	998,00	1234,00	2207,00	1502,00	1767,00	1436,00	1325,00	1785,00	1715,00	1634,00
6	31	1597,00	1627,00	1972,00	2546,00	3069,00	3176,00	3528,00	4406,00	5339,00	6139,00

INTERACTIVITY AFFINITIES

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
1	1	1,00	,50	,50	,90	,00	,00	,40	,00	,00	,00
1	11	,55	,00	,00	,00	,50	,10	,00	,00	,00	,00
1	21	,00									

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
2	1	,50	1,00	1,00	,00	,00	,00	,40	,00	,00	,35
2	11	,45	,00	,00	,00	,50	,10	,00	,00	,00	,00
2	21	,00									

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
3	1	,50	1,00	1,00	,00	,00	,50	,00	,00	,00	,85
3	11	,00	,00	,00	,25	,00	,00	,00	,00	,35	,40
3	21	,00									

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
4	1	,90	,00	,00	1,00	,50	,50	,40	,00	,00	,65
4	11	,40	,00	,00	,30	,50	,10	,00	,00	,00	,00
4	21	,00									

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
5	1	,00	,00	,00	,50	1,00	1,00	,00	,00	,00	,65
5	11	,40	,00	,00	,30	,50	,10	,00	,00	,00	,00
5	21	,00									

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
6	1	,00	,00	,50	,50	1,00	1,00	,00	,00	,00	,20
6	11	,00	,00	,00	,00	,00	,00	,00	,00	,25	,40
6	21	,00									

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
7	1	,40	,40	,00	,40	,00	,00	1,00	,80	,95	,35
7	11	,60	,00	,00	,60	,50	,10	,00	,00	,00	,00
7	21	,00									

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
8	1	,00	,00	,00	,00	,00	,00	,80	1,00	,75	,25
8	11	,00	,00	,00	,00	,50	,10	,00	,00	,00	,00
8	21	,00									

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
9	1	,00	,00	,00	,00	,00	,00	,95	,75	1,00	,85
9	11	,00	,00	,60	,00	,00	,00	,00	,00	,00	,00
9	21	,00									

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10

GROWTH RATIOS BY CYCLE

	ACTIVITY	CYCLE 1	CYCLE 2	CYCLE 3	CYCLE
1	HUM LECT	1.100	1.350	1.650	
2	HUM LAB	1.100	1.350	1.650	
3	HUM O/R	1.200	1.600	2.000	
4	S S LCT	1.250	1.500	1.750	
5	S S LAB	1.250	1.500	1.750	
6	S S O/R	1.100	1.300	1.600	
7	SCI LCT	1.250	1.500	2.000	
8	SCI LAB	1.250	1.500	2.000	
9	SCI RSCH	1.200	1.400	1.600	
10	SCI OFF	1.200	1.400	1.600	
11	ENG LCT	1.050	1.100	1.150	
12	ENG LAB	1.050	1.100	1.150	
13	ENG RSCH	1.100	1.200	1.300	
14	ENG OFF	1.050	1.100	1.170	
15	RESDENTL	1.000	1.000	1.000	
16	STUDY	1.100	1.350	1.650	
17	RECRIN I	1.050	1.050	1.100	
18	RECRIN O	1.250	1.500	1.650	
19	GEN ADMN	1.100	1.250	1.500	
20	AUXLRY	1.050	1.100	1.200	
21	PUBLIC	1.050	1.100	1.200	

	ACTIVITY	MINIMUM UTILIZATION	MAXIMUM UTILIZATION	GROWTH RULE	ACTIVITY LEVEL	CURRENT UTILIZATION	TOTAL AREA
1	HUM LECT	.500	1.000	1	18372.	.950	50326.
2	HUM LAB	.400	1.000	2	6442.	.500	33269.
3	HUM O/R	.900	1.000	3	3278.	.920	52064.
4	S S LCT	.500	1.000	4	20361.	.800	51646.
5	S S LAB	.400	1.000	5	0.	.000	19250.
6	S S O/R	.900	1.000	6	2992.	.950	51596.
7	SCI LCT	.500	1.000	7	8272.	.500	49968.
8	SCI LAB	.400	1.000	8	8908.	.350	139457.
9	SCI RSCH	.500	1.000	9	1685.	1.100	4567.
10	SCI OFF	.900	1.000	10	845.	3.500	47099.
11	ENG LCT	.500	1.000	11	1114.	1.250	7549.
12	ENG LAB	.400	1.000	12	160.	.800	22658.
13	ENG RSCH	.350	1.000	13	572.	2.100	255.
14	ENG OFF	.900	1.000	14	286.	.950	9313.
15	RESDENTL	.750	1.000	15	300800.	1.000	552771.
16	STUDY	.850	1.000	16	111340.	.900	69746.
17	RECRTN 1	.850	1.000	17	120100.	.900	76664.
18	RECRTN 0	.850	1.000	18	199475.	.000	0.
19	GEN ADMN	.850	1.000	19	5000.	.900	268689.
20	AUXLRY	.500	1.000	20	3500.	.750	45247.
21	PUBLIC	.300	1.000	21	800.	.650	23604.

ZONE	SQUARE FEET ASSIGNED BY SPACE TYPE										ZONE TOTAL	ZONE MAX
	CLASS	LAB	OFFICE	STUDY	SPECIAL	GENERAL	SUPPORT	HOUSING	FOOD	ATHLETIC		
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000
4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000
5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
6	12196.	30456.	19485.	4822.	0.	642.	13444.	0.	0.	0.	81047.	100000
7	4121.	94582.	22721.	5282.	366.	3770.	4733.	0.	0.	0.	135575.	100000
8	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	100000
9	7088.	0.	12676.	32767.	0.	4677.	8939.	0.	0.	0.	66147.	100000
10	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	100000
12	1287.	0.	24845.	0.	927.	1072.	4984.	0.	186.	36870.	70169.	750000
13	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000
14	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000
15	0.	0.	296.	0.	0.	16337.	0.	0.	0.	0.	16633.	17000
16	9630.	22658.	11687.	5998.	255.	0.	4733.	0.	438.	0.	55399.	140000
17	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0
18	4950.	25496.	4526.	1800.	0.	0.	10274.	0.	0.	0.	47046.	60000.
19	13241.	1694.	36479.	2126.	3188.	2741.	2942.	0.	130.	0.	62541.	66000.
20	0.	0.	8820.	0.	401.	6606.	513.	0.	2095.	2277.	20722.	110000.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
22	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
23	2171.	0.	1900.	0.	0.	183.	967.	279.	0.	31490.	36990.	100000.
24	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
25	0.	0.	0.	0.	0.	3515.	0.	32767.	178.	0.	36460.	50000.
26	0.	0.	0.	0.	0.	1768.	0.	13041.	0.	0.	14809.	15000.
27	0.	0.	6117.	0.	87.	14007.	7976.	50.	41264.	0.	69501.	125000.
28	0.	0.	1206.	0.	0.	8295.	0.	32767.	0.	0.	42348.	250000.
29	0.	0.	0.	0.	0.	0.	0.	7801.	0.	0.	7801.	60000.
30	5572.	0.	28703.	0.	0.	403.	7552.	0.	172.	0.	42382.	115000.
31	14079.	0.	12985.	0.	469.	1062.	301.	0.	77.	0.	28993.	115000.
32	5201.	18293.	11159.	0.	396.	2625.	2983.	0.	127.	0.	40784.	125000.
33	0.	0.	91.	0.	0.	1110.	2548.	32767.	0.	0.	36516.	40000.
34	0.	0.	0.	0.	0.	0.	0.	26742.	1538.	0.	28280.	40000.
35	0.	0.	4804.	0.	0.	0.	177.	0.	0.	0.	4981.	15000.
36	0.	0.	12770.	0.	3376.	842.	1917.	0.	0.	0.	18905.	20000.
37	609.	37.	6069.	0.	540.	421.	147.	0.	0.	0.	7823.	-0.
38	0.	0.	1680.	0.	0.	162.	593.	0.	0.	0.	2435.	15000.
39	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15000.
40	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15000.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15000.
42	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15000.
43	0.	0.	0.	0.	0.	0.	0.	181.	0.	0.	181.	0.
44	0.	0.	0.	0.	0.	0.	0.	17403.	0.	0.	17403.	20000.
45	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	40000
46	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	40000
47	5153.	9678.	8334.	186.	2353.	5352.	2248.	0.	0.	0.	33304.	35000.
48	1212.	0.	1662.	326.	0.	0.	516.	936.	0.	21822.	26476.	150000.
49	0.	0.	957.	0.	0.	1331.	1710.	0.	510.	0.	4508.	100000.
50	0.	0.	110.	0.	0.	0.	278.	30444.	6424.	0.	37256.	50000.
51	0.	0.	0.	0.	0.	266.	6366.	0.	0.	0.	6632.	0.
52	8309.	327.	12946.	0.	0.	437.	915.	10858.	228.	0.	34020.	25000.
53	11324.	2102.	13123.	0.	306.	1166.	14.	23366.	237.	0.	51638.	130000.
54	0.	0.	2180.	20493.	0.	467.	27.	22265.	241.	0.	45673.	50000.
55	0.	6694.	1669.	184.	0.	4297.	494.	19902.	327.	0.	33567.	35000.
56	0.	0.	3384.	184.	0.	1153.	318.	20448.	230.	0.	25755.	40000.
57	0.	0.	900.	0.	0.	2584.	3431.	18391.	19287.	0.	44569.	40000.
58	0.	0.	47.	155.	0.	7558.	2572.	16086.	3372.	6270.	37119.	40000

59	0.	0.	9501.	0.	0.	8693.	0.	23425.	138.	0.	41557.	140000.
60	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	35000.	20000.	297.	0.	0.	0.	0.	0.	0.	0.	55297.	1000000.
62	0.	625.	31490.	390.	0.	339.	36145.	0.	413.	0.	69402.	150000.
63	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	10000.
64	0.	0.	3359.	0.	0.	1104.	16447.	0.	0.	0.	20910.	50000.
65	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	100000.
66	0.	0.	0.	0.	0.	0.	0.	28146.	0.	0.	28146.	50000.
67	0.	0.	456.	0.	0.	292.	996.	32767.	12457.	0.	46970.	50000.
68	0.	0.	0.	1898.	0.	337.	319.	15594.	0.	0.	18148.	50000.

ZONE	SQUARE FEET OF VACANT SPACE BY TYPE										ZONE TOTAL
	CLASS	LAB	OFFICE	STUDY	SPECIAL	GENERAL	SUPPORT	HOUSING	FOOD	ATHLETIC	
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	20000.	0.	0.	0.	0.	0.	0.	0.	20000.
13	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
49	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
51	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
52	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

****

***** MEASURE OF EFFECTIVENESS = 59.13658 *****

****

PLAN 1
CYCLE 1
FUNDS AVAILABLE = $ 10000000.

ACTIVITY VALUES

1	HUM LECT	= 20209.
2	HUM LAB	= 7086.
3	HUM O/R	= 3934.
4	S S LCT	= 25451.
5	S S LAB	= 0.
6	S S O/R	= 3291.
7	SCI LCT	= 10340.
8	SCI LAB	= 11135.
9	SCI RSCH	= 2022.
10	SCI OFF	= 1014.
11	ENG LCT	= 1170.
12	ENG LAB	= 168.
13	ENG RSCH	= 629.
14	ENG OFF	= 300.
15	RESDENTL	= 300800.
16	STUDY	= 122474.
17	RECRTN 1	= 126105.
18	RECRTN 0	= 249344.
19	GEN ADMN	= 5500.
20	AUXLRY	= 3675.
21	PUBLIC	= 840.

PLAN 1
CYCLE 1

CRITICAL ACTIVITIES (UTILIZATION)

	ACTIVITY	CURRENT UTILIZATION	MAXIMUM UTILIZATION	MINIMUM UTILIZATION	PRIORITY INDEX	AREA FOR UMIN	AREA FOR UMAX
10	SCI OFF	4.200	1.000	.900	32.000	172696.	150717.
13	ENG RSCH	2.310	1.000	.350	2.015	1426.	334.
3	HUM O/R	1.104	1.000	.900	1.040	11801.	5415.
9	SCI RSCH	1.320	1.000	.500	.640	7490.	1461.
11	ENG LCT	1.312	1.000	.500	.625	12267.	2359.
6	S S O/R	1.045	1.000	.900	.450	8313.	2322.
1	HUM LECT	1.045	1.000	.500	.090	54355.	2265.

CRITICAL ACTIVITIES (NO SPACE)

ACTIVITY	ACTIVITY LEVEL	ASSIGNED SPACE	AREA FOR MINIMUM UTILIZATION	AREA FOR MAXIMUM UTILIZATION
NONE				

CRITICAL ACTIVITIES (SPACE CONDITION)

	ACTIVITY	ZONE	AREA
15	RESDENTL	57	18381.

CRITICAL ZONES (DENSITY)

ZONE	CURRENT AREA	ALLOWABLE AREA	EXCESS	ACTIVITY	ASSIGNED AREA
37	7823.	-0.	7823.		
				19 GEN ADMN	6310.
				20 AUXLRY	1513.
43	181.	0.	181.		
				19 GEN ADMN	181.
51	6632.	0.	6632.		
				19 GEN ADMN	6632.
52	34020.	25000.	9020.		
				1 HUM LECT	4011.
				3 HUM O/R	4517.
				4 S S LCT	4735.
				5 S S LAB	327.

				6 S S O/R	7455,
				7 SCI LCT	451,
				10 SCI OFF	363,
				15 RESDENTL	11697,
				19 GEN ADMN	464,
	57	44589,	40000,	4589,	
				15 RESDENTL	44507,
				19 GEN ADMN	82,

PLAN 1
CYCLE 1
PROJECT 1

EARLIEST CYCLE = 1
LATEST CYCLE = 4

CYCLE CRITICAL

ACTIVITY	ZONE	ACTION	QUANTITY	COST	LUMP SUM	TOTAL COST	UTILIZATION
15 RESDENTL	57	DESTROY	19287,	.00	12500,	12500,	1,036
15 RESDENTL	57	DESTROY	18381,	.00	15000,	15000,	1,073
19 GEN ADMN	57	DESTROY	82,	.00	25,	25,	.990
13 ENG RSCH	16	BUILD	1400,	21.00	21000,	29400,	.356

PLAN 1
CYCLE 1
PROJECT 2

EARLIEST CYCLE = 2
LATEST CYCLE = 4

PROJECT 2 NOT CRITICAL, CYCLE NOT CRITICAL

PROJECT ACTIVITIES NOT CRITICAL

PLAN 1
CYCLE 1
PROJECT 3

EARLIEST CYCLE = 1
LATEST CYCLE = 4

CYCLE CRITICAL

ACTIVITY	ZONE	ACTION	QUANTITY	COST	LUMP SUM	TOTAL COST	UTILIZATION
10 SCI OFF	13	BUILD	300000,	18,00	100000,	5400000,	,570
3 HUM O/R	12	ADD	6000,	5,00	1000,	41000,	,957
6 S S O/R	12	ADD	9000,	5,00	1500,	46500,	,890

PLAN 1
CYCLE 1
PROJECT 4

EARLIEST CYCLE = 2
LATEST CYCLE = 4

PROJECT 4 NOT CRITICAL, CYCLE NOT CRITICAL

PROJECT ACTIVITIES NOT CRITICAL

PLAN 1
CYCLE 1
PROJECT 5

EARLIEST CYCLE = 1
LATEST CYCLE = 1

CYCLE CRITICAL

ACTIVITY	ZONE	ACTION	QUANTITY	COST	LUMP SUM	TOTAL COST	UTILIZATION
15 RESDENTL	25	IMPROVE	32767,	4,50	25000,	172451,	1,073

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***** MEASURE OF EFFECTIVENESS = 63.66871 *****

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FUNDS AVAILABLE $ 10000000.
CYCLE COST 5689351.

BALANCE 4310649.

MAINTENANCE COST REPORT FOR CYCLE 1

SPACE TYPE	QUANTITY	UNIT COST	COST
1	141143.	1.50	211714.
2	232644.	1.80	418759.
3	619328.	1.65	1021891.
4	76613.	1.50	114920.
5	14084.	2.00	28168.
6	105728.	1.70	179738.
7	148656.	1.65	245282.
8	445599.	2.05	913478.
9	109364.	1.50	164046.
10	98729.	1.50	148093.
		TOTAL COST	3446090.

CRITICAL ACTIVITIES (UTILIZATION)

	ACTIVITY	CURRENT UTILIZATION	MAXIMUM UTILIZATION	MINIMUM UTILIZATION	PRIORITY INDEX	AREA FOR UMIN	AREA FOR UMAX
9	SCI RSCH	1.320	1.000	.500	.640	7490.	1461.
11	ENG LCT	1.312	1.000	.500	.625	12267.	2359.
15	RESDENTL	1.073	1.000	.750	.293	221925.	37668.
1	HUM LECT	1.045	1.000	.500	.090	54855.	2265.
10	SCI OFF	.570	1.000	.900	3.301	-127304.	-149283.
6	S S O/R	.890	1.000	.900	.102	-687.	-6678.

CRITICAL ACTIVITIES (NO SPACE)

ACTIVITY	ACTIVITY LEVEL	ASSIGNED SPACE	AREA FOR MINIMUM UTILIZATION	AREA FOR MAXIMUM UTILIZATION
NONE				

CRITICAL ACTIVITIES (SPACE CONDITION)

	ACTIVITY	ZONE	AREA
15	RESDENTL	57	-0.

CRITICAL ZONES (DENSITY)

ZONE	CURRENT AREA	ALLOWABLE AREA	EXCESS	ACTIVITY	ASSIGNED AREA
13	300000.	50000.	250000.		
				10 SCI OFF	300000.
37	7823.	-0.	7823.		
				19 GEN ADMN	6310.
				20 AUXLRY	1513.
43	181.	0.	181.		
				19 GEN ADMN	181.
51	6632.	0.	6632.		
				19 GEN ADMN	6632.
52	34020.	25000.	9020.		
				1 HUM LECT	4011.
				3 HUM O/R	4517.
				4 S S LCT	4735.
				5 S S LAB	327.
				6 S S O/R	7455.
				7 SCI LCT	451.
				10 SCI OFF	363.
				15 RESDENTL	11697.
				19 GEN ADMN	464.
57	82339.	40000.	42339.		
				15 RESDENTL	6839.

PLAN 1 SUMMARY

CYCLE	PROJECT 1	2	3	4	5
1	X	0	X	0	X
2	0	X	0	X	0
3	0	0	0	0	0

X = PROJECT EXECUTED
0 = PROJECT NOT EXECUTED

	ACTIVITY	MINIMUM UTILIZATION	MAXIMUM UTILIZATION	GROWTH RULE	ACTIVITY LEVEL	CURRENT UTILIZATION	TOTAL AREA
1	HUM LECT	.500	1.000	1	30314.	1.308	60326.
2	HUM LAB	.400	1.000	2	10629.	.825	33269.
3	HUM O/R	.900	1.000	3	6556.	1.595	60064.
4	S S LCT	.500	1.000	4	35632.	1.400	51646.
5	S S LAB	.400	1.000	5	0.	.000	19250.
6	S S, O/R	.900	1.000	6	4787.	1.294	60596.
7	SCI LCT	.500	1.000	7	16544.	1.000	49968.
8	SCI LAB	.400	1.000	8	17816.	.700	139457.
9	SCI RSCH	.500	1.000	9	2696.	1.760	4567.
10	SCI OFF	.900	1.000	10	1352.	.760	347099.
11	ENG LCT	.500	1.000	11	1281.	1.457	7549.
12	ENG LAB	.400	1.000	12	184.	.920	22658.
13	ENG RSCH	.350	1.000	13	744.	.421	1655.
14	ENG OFF	.900	1.000	14	335.	1.111	9313.
15	RESDENTL	.750	1.000	15	300800.	.870	635103.
16	STUDY	.850	1.000	16	183711.	1.485	69746.
17	RECRTN I	.850	1.000	17	132110.	.990	78664.
18	RECRTN O	.850	1.000	18	329134.	.000	0.
19	GEN ADMN	.850	1.000	19	7500.	1.138	318607.
20	AUXLRY	.500	1.000	20	4200.	.900	45247.
21	PUBLIC	.300	1.000	21	960.	.780	23604.

ZONE	SQUARE FEET ASSIGNED BY SPACE TYPE										ZONE TOTAL	ZONE MAX
	CLASS	LAB	OFFICE	STUDY	SPECIAL	GENERAL	SUPPORT	HOUSING	FOOD	ATHLETIC		
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
6	12196.	30458.	19485.	4822.	0.	642.	13444.	0.	0.	0.	81047.	100000.
7	4121.	94582.	22721.	5282.	366.	3770.	4733.	0.	0.	0.	135575.	100000.
8	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	100000.
9	7088.	0.	12676.	32767.	0.	4677.	8939.	0.	0.	0.	66147.	100000.
10	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	100000.
12	1287.	0.	24843.	0.	927.	1072.	4984.	0.	186.	36870.	70169.	75000.
13	0.	0.	300000.	0.	0.	0.	0.	0.	0.	0.	300000.	50000.
14	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
15	0.	0.	296.	0.	0.	16337.	0.	0.	0.	0.	16633.	17000.
16	9630.	22658.	11687.	5998.	1655.	0.	4733.	0.	436.	0.	56799.	140000.
17	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
18	4950.	25496.	4526.	1800.	0.	0.	10274.	0.	0.	0.	47046.	60000.
19	13241.	1694.	36479.	2126.	3188.	2741.	2942.	0.	130.	0.	62541.	66000.
20	0.	0.	8820.	0.	401.	6608.	513.	0.	2095.	2277.	20722.	110000.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
22	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
23	2171.	0.	1900.	0.	0.	183.	967.	279.	0.	31490.	36990.	100000.
24	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
25	0.	0.	0.	0.	0.	3515.	0.	32767.	178.	0.	36460.	50000.
26	0.	0.	0.	0.	0.	1768.	0.	13041.	0.	0.	14809.	15000.
27	0.	0.	6117.	0.	87.	14007.	7976.	50.	41264.	0.	69501.	125000.
28	0.	0.	1286.	0.	0.	8295.	0.	132767.	20000.	0.	162348.	250000.
29	0.	0.	0.	0.	0.	0.	0.	7801.	0.	0.	7801.	60000.
30	5572.	0.	28705.	0.	0.	403.	7532.	0.	172.	0.	42382.	115000.
31	14079.	0.	12985.	0.	489.	1062.	301.	0.	77.	0.	28993.	115000.
32	5201.	18293.	11159.	0.	396.	2625.	2903.	0.	127.	0.	40784.	125000.
33	0.	0.	91.	0.	0.	1110.	2548.	32767.	0.	0.	36516.	40000.
34	0.	0.	0.	0.	0.	0.	0.	26742.	1538.	0.	28280.	40000.
35	0.	0.	4804.	0.	0.	0.	177.	0.	0.	0.	4981.	15000.
36	0.	0.	12770.	0.	3376.	642.	1917.	0.	0.	0.	18905.	20000.
37	609.	37.	6069.	0.	540.	421.	147.	0.	0.	0.	7823.	-0.
38	0.	0.	1680.	0.	0.	162.	593.	0.	0.	0.	2435.	15000.
39	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15000.
40	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15000.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15000.
42	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15000.
43	0.	0.	0.	0.	0.	0.	0.	181.	0.	0.	181.	0.
44	0.	0.	0.	0.	0.	0.	0.	17403.	0.	0.	17403.	20000.
45	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	40000.
46	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	40000.
47	5153.	9678.	8334.	186.	2353.	5352.	2248.	0.	0.	0.	33304.	35000.
48	1212.	0.	1662.	328.	0.	0.	516.	936.	0.	21822.	26476.	150000.
49	0.	0.	957.	0.	0.	1331.	1710.	0.	510.	0.	4508.	100000.
50	0.	0.	110.	0.	0.	0.	278.	30444.	6424.	0.	37256.	50000.
51	0.	0.	0.	0.	0.	266.	6366.	0.	0.	0.	6632.	-0.
52	8309.	327.	12946.	0.	0.	437.	915.	10856.	228.	0.	34020.	25000.
53	11324.	2102.	13123.	0.	306.	1166.	14.	23366.	237.	0.	51638.	130000.
54	0.	0.	2180.	20493.	0.	467.	27.	22265.	241.	0.	45673.	50000.
55	0.	6694.	1669.	184.	0.	4297.	494.	19902.	327.	0.	33567.	35000.
56	0.	0.	3384.	184.	0.	1153.	348.	20446.	236.	0.	25755.	40000.
57	0.	0.	906.	0.	0.	2066.	3431.	36762.	38574.	0.	82339.	40000.
58	10000.	0.	50047.	155.	0.	7588.	2699.	16088.	3372.	6270.	97019.	40000.

60	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	35000.	20000.	297.	0.	0.	0.	0.	0.	0.	0.	55297.	1000000.
62	0.	625.	31490.	390.	0.	339.	36145.	0.	413.	0.	69402.	1500000.
63	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	100000.
64	0.	0.	3359.	0.	0.	1104.	16447.	0.	0.	0.	20910.	500000.
65	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1000000.
66	0.	0.	0.	0.	0.	0.	0.	28146.	0.	0.	28146.	500000.
67	0.	0.	456.	0.	0.	292.	996.	32767.	12457.	0.	46970.	500000.
68	0.	0.	0.	1898.	0.	337.	319.	15594.	0.	0.	18148.	500000.

ZONE	SQUARE FEET OF VACANT SPACE BY TYPE										ZONE TOTAL
	CLASS	LAB	OFFICE	STUDY	SPECIAL	GENERAL	SUPPORT	HOUSING	FOOD	ATHLETIC	
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	3000.	0.	0.	0.	0.	0.	0.	0.	3000.
13	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
49	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
51	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
52	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

54	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
55	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
56	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
57	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
58	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
59	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
60	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	35000.	20000.	0.	0.	0.	0.	0.	0.	0.	55000.	
62	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
63	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
64	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
65	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
66	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
67	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
68	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

****

***** MEASURE OF EFFECTIVENESS = 63.11942 *****

****

CRITICAL ACTIVITIES (UTILIZATION)

	ACTIVITY	CURRENT UTILIZATION	MAXIMUM UTILIZATION	MINIMUM UTILIZATION	PRIORITY INDEX	AREA FOR UMIN	AREA FOR UMAX
3	HUM O/R	1.595	1.000	.900	5.949	46378.	35734.
16	STUDY	1.485	1.000	.850	3.233	52104.	33827.
6	S S O/R	1.294	1.000	.900	2.942	26544.	17830.
9	SCI RSCH	1.760	1.000	.500	1.520	11509.	3471.
14	ENG OFF	1.111	1.000	.900	1.115	2189.	1038.
19	GEN ADMN	1.138	1.000	.850	.923	108134.	44123.
11	ENG LCT	1.437	1.000	.500	.875	14154.	3303.
4	S S LCT	1.400	1.000	.500	.800	92963.	20650.
1	HUM LECT	1.308	1.000	.500	.615	97446.	18560.
10	SCI OFF	.760	1.000	.900	1.401	-54039.	-83345.

CRITICAL ACTIVITIES (NO SPACE)

ACTIVITY	ACTIVITY LEVEL	ASSIGNED SPACE	AREA FOR MINIMUM UTILIZATION	AREA FOR MAXIMUM UTILIZATION
NONE				

CRITICAL ACTIVITIES (SPACE CONDITION)

ACTIVITY	ZONE	AREA
NONE		

CRITICAL ZONES (DENSITY)

ZONE	CURRENT AREA	ALLOWABLE AREA	EXCESS	ACTIVITY	ASSIGNED AREA

13	300000.	50000.	250000.		
				10 SCI OFF	300000.
37	7823.	-0.	7823.		
				19 GEN ADMN	6310.
				20 AUXLRY	1513.
43	181.	0.	181.		
				19 GEN ADMN	181.
51	6632.	0.	6632.		
				19 GEN ADMN	6632.
52	34020.	25000.	9020.		
				1 HUM LECT	4011.
				3 HUM O/R	4517.
				4 S S LCT	4735.
				5 S S LAB	327.
				6 S S O/R	7455.
				7 SCI LCT	451.
				10 SCI OFF	363.
				15 RESDENTL	11697.
				19 GEN ADMN	464.

57	82339.	40000.	42339.		
				15 RESDENTL	6839.
58	97019.	40000.	57019.		
				1 HUM LECT	10000.
				15 RESDENTL	26648.
				16 STUDY	155.
				19 GEN ADMN	59020.
				21 PUBLIC	1196.

THE FOLLOWING REPORT REFLECTS YEARLY BALANCES ASSUMING BUILDING COSTS ARE DISTRIBUTED OVER A THREE YEAR PERIOD

CYCLE...	1	ADJUSTED YEARLY BALANCE...	4310649.00
CYCLE...	2	ADJUSTED YEARLY BALANCE...	15210648.90
CYCLE...	3	ADJUSTED YEARLY BALANCE...	35210649.00

		CONSTRUCTION COSTS	RENOVATION COSTS	MAINTENANCE COSTS
CYCLE	1	5429400.	259951.	3446090.
CYCLE	2	4100000.	0.	3778590.
CYCLE	3	0.	0.	3778590.
TOTALS....		9529400.	259951.	11003269.

APPENDICES

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APPENDIX 1. DATA CARD SEQUENCE AND CONTENTS

The following sequence of data cards must be followed for use in the evaluator program. An incorrect number of data cards or the omission of a delimiter card will cause termination of the run, and the user must verify his data and reexecute the programs. Card types, contents and sequence are identified in the following list:

Card Type 1 Denotes the number of plans to be investigated by a single run of the program.

Card Type 2 The limits for number of cycles, number of activities, zones, projection rules, projects, affinity rules, and space types.

Card Type 3 The literal "FUNDS" in card columns 1-5. (Denotes funds card will follow.)

Card Type 4 Funds card — the beginning cycle of that card and the dollars budgeted for construction in seven cycles beginning with the cycle denoted in columns 1-4. Multiple cards may be required for a plan which extends over more than seven cycles.

Card Type 5 Gives activity data: index number, name, base quantity, maximum, minimum and base utilizations and the index of the growth rule to be used for that activity.

Card Type 6 Delimiter — the literal "*" in card column 1.

Card Type 7 Density header: the literal "DENSITY" in card columns 1-7. (Denotes zone density cards will follow.)

Card Type 8 Zone densities: zone number, space type, maximum space (of all types) that may be assigned in this zone, and vacant space by space type in that zone. A maximum of eight space types is permitted.

Card Type 6 Delimiter: "*" in card column 1.

Card Type 9 Space header: "SPACE" in card columns 1-5. (Denotes space assignment cards will follow.)

Card Type 10 Space assignments: activity number, zone number, space type index, net square feet of space type "ST" in zone "Z" assigned to activity "I"; net-to-gross factor to convert net square feet to gross square feet (by multiplication).

Card Type 6 Delimiter: "*" in card column 1.

Card Type 11 Distance header: "DISTANCES" in card columns 1-9. (Denotes interzone distance cards will follow.)

50 **Card Type 12** Interzone distances: the originating zone (from), the destination zone (to), the distance from zone "Z" to each of the other zones with nine distances per card.

Card Type 6 Delimiter: "*" in card column 1.

Card Type 13 Affinity header: "AFFINITIES" in card columns 1-10. (Denotes interactivity affinity cards will follow.)

Card Type 14 Interactivity affinities: index of originating activity (I), index of activity (IPR) for first affinity, activity I's need for proximity to activity IPR, IPR + I, IPR + 2. . . . (There can be nine affinities per data card.)

Card Type 6 Delimiter: "*"in card column 1.

Card Type 15 Rules header card: "RULES" in card columns 1-5. (Denotes projection rules or ratios will follow.)

Card Type 16 Projection rules – projection rule number and the growth ratios by cycle where the growth ratio is the ratio of the activity level in a given cycle related to the level in the base cycle.

Card Type 6 Delimiter: "*" in card column 1.

Card Type 17 Cost header: "COST" in card columns 1-4.

Card Type 18 Costs: maintenance, renovation and construction costs per gross square foot by space type.

Card Type 6 Delimiter: "*" in card column 1.

Card Type 19 Proximity coefficient: "CENTRALIZATION" and the percent contribution of proximity to the measure of effectiveness (BETA-1).

Card Type 20 Central zone density coefficient: "CENTRAL," percent of maximum density ideal for central zones and percent contribution of central zone density to measure of effectiveness (BETA-2, 1).

Card Type 21 Secondary zones density coefficient: "SECONDARY," percent of maximum density ideal for secondary zones, percent contribution of secondary zone density to the measure of effectiveness (BETA-2, 2).

Card Type 22 Remote zones density coefficient: "REMOTE," percent

of maximum density ideal for remote zones, percent distribution of remote zone density to the measure of effectiveness (BETA-2, 3).

Card Type 23 Zone Type: "ZONE" in card columns 1-4; zone number; type zone (C = central, S = secondary, R = remote)

Card Type 6 Delimiter: "*" in card column 1.

Card Type 24 Utilization Coefficient: "UTILIZE" in card column 1-7; percent utilization considered ideal, percent contribution utilization makes to measure of effectiveness.

Card Type 25 Project cards: first cycle (earliest) in which project may be executed; project criticality (C = project is definitely critical, blank = project may be critical depending upon status of the associated activities); latest cycle in which project may be executed; as many as three activity indicies for which this project contains actions (if any one of the three activities are critical within the time limits specified above, all actions associated with the project are executed and will probably envolve all three activities); number of action cards which can be expected to follow.

Card Type 26 Actions: activity index number, zone, space type, net square feet, action (A = add space to inventory for activity, space type and zone; B = build space and add to inventory; D = demolish space and remove from inventory; I = improve space by spending money but without altering the inventory; S = subtract space from the inventory for the activity, space type and zone), total cost for the action, net-to-gross factor to convert net square feet to gross area.

APPENDIX 2. PROGRAM AND PURPOSE

The following list identifies the programs required in the evaluation system and a brief description of their purposes. Each program is identified further as a mainline (M) or subroutine (SR). The programs were implemented in Fortran IV on the Univac 1108.

PROGRAM		PROGRAM
MAIN	M	The one executable mainline program in this evaluation model system. It controls the reading of input data and the execution of projects and actions. It calculates the yearly balances of building costs and controls the printing of reports.
INPUT	SR	Reads the majority of input data which describe the campus and resources available. It reads base data on funds, activities, density limits, vacant space, space assignments, interzone distances, interactivity affinities, projection rules for activities, measure of effectiveness parameter cards, zone types. Various errors in input are flagged by diagnostics which are listed in Appendix 4.
INITL	SR	Summarizes and prints space assigned by activity, vacant space by zone and type, initial utilization, initial level of activity, initial utilizations and measure of effectiveness.
TAPE	SR	Reads project and action information from cards and stores on magnetic tape.
NEEDS	SR	Lists projected space required for the final cycle of the current plan.
PSUMRY	SR	Prints a summary of projects executed by phase. In this matrix, an "X" represents the project executed, an "O" represents project not executed.
MEFF2	SR	Computes the measure of effectiveness. Arguments supplied are Arrays of indices to those activities having affinities greater than or equal to .5 or less than or equal to –.5. The maximum interzone distance DMAX. The minimum interzone distance DMIN. Weighting factor for proximity DATA1. Maximum index for SIGAF1: MX1NDX. Maximum index for SIGAF2: MX2NDX.

Weighting factor for Density DATA2.

Weighting factor for Utilization DATA3.

Ideal value of density for central zones CNTRL.

Ideal value of density for secondary zones SCNDRY.

Ideal value of density for remote zones REMOTE.

Array of ideal utilization values UIDEAL (I).

Array of zone types ZARRAY (Z).

TABL1 SR — Prints for each activity the minimum utilization, maximum utilization, growth in activity level, current utilization of its total area.

Prints for each zone the square feet assigned by space type, zone total and zone maximum density allowed.

Prints for each zone the square feet of vacant space by space type and a zone total.

Prints the measure of effectiveness.

ACRIT SR — Lists activities which are critical due to utilization, lack of space assigned (no space), space condition or zones which are critical due to density.

FINTOT SR — Prints adjusted (distributed) building costs by cycle renovation and maintenance costs by cycle.

APROJ SR — Projects an activity level for a given cycle by using the base level of activity times the appropriate value of the projection rule.

UCALC SR — Calculates current utilization value for a given activity in a given cycle.

UCRIT SR — Checks activity for criticality due to utilization, no space, density being exceeded or condition of space.

ACTION SR — Executes actions of **add, build, dimolish, subtract** or **improve.** Makes the adjustments to space assigned to activities, calculates the associated costs and prints the information.

SPACT SR — Summarizes total space assigned to each activity by space type and prints the report.

54 **SMNCST** SR	Accumulates maintenance costs for each space type.	

APPENDIX 3. MEASURE OF EFFECTIVENESS – COMPUTATIONAL TECHNIQUES, AND PROGRAM FLOW

As discussed in the main text of this volume, the measure of effectiveness is computed relative to ideal values, which are intended to be fixed at the start of the given program execution. These ideal values are determined by input of the weighting factors and percentages of density and utilization. The following discussion describes the techniques employed in computing these fixed values within the routine INPUT and the manner in which such values are used in the routine MEFF2.

Consider proximity first. The maximum interzone distance (DMAX) is determined by searching array DIST (interzone distances). An array of indices for all activities between which there exists an affinity greater than or equal to .5 is created and stored in array SIGAF1. Correspondingly, an array which is used to store the indices representing those activities between which there exists an affinity of value less than or equal to -.5 are stored in array SIGAF2. Upon completion of the logging of the requisite indices in these two arrays, the following parameters required by the routine MEFF2 have been determined:

The indexing arrays SIGAF1, SIGAF2

DMAX, the maximum interzone distance

MAXINDEX1, indicating the total number of interactivity affinities having a value greater than or equal to .5

MAXINDEX2, the total number of activities having an interactivity affinity less than or equal to -.5

DMIN, the minimum interzone distance which is assumed to be 1.

The manner in which these parameters are used in subroutine MEFF2 is as follows: First, SIGAF1 and SIGAF2 have been triangularized; that is, as affinities are identified between activities, the indices are logged in the arrays in a manner in which there are no repetitions. Computation proceeds by selecting a given activity and locating all zones in which it occurs. For each zone in which a given activity is found, the level of this activity in that zone is multiplied by the level of a

second activity in every other zone. A new zone for the first activity is then located. Again, the product of activity level for the first activity in the selected zone is multiplied by the activity level in all zones for the second activity. As this process continues for SIGAF1 or for those activities exhibiting a strong affinity, the summation of all the products is accumulated.

This process is repeated for SIGAF2 and the summation of those cross products is accumulated. The two accumulated cross products are then multiplied by their corresponding distance value. For weak affinities, the distance value is the maximum interzone distance (DMAX) and for strong affinities, the minimum interzone distance (DMIN). The ideal value is taken to be the average of the two ideals. It would seem that to realize this ideal value would be very nearly impossible. It would be better if an arbitrary multiplicative factor less than 1 were chosen by which this ideal value would be multiplied. It is implemented in the program as .7; however it would be an improvement to have this as a program input. It should depend upon the campus and the distribution of the activities in the zones and, therefore, should be determined for each individual campus.

The ideal density value is computed by first examining the input designating each zone as *central, remote* or *secondary*. An array called ZARRAY is created in the routine INPUT and contains for each zone a value representing its zone type. *1* for *central, 2* for *secondary* and *3* for *remote.* Additionally, for each of the zone classes, an ideal density value is computed by multiplying the maximum allowable density level by the factor which determines the percent of maximum value which is to be thought ideal for each of the classes of zone. These ideal density values for each of the zone types are computed a single time during execution of program INPUT and are compared with actual values throughout the run on call to subroutine MEFF2.

Within subroutine MEFF2 the density contribution to the measure of effectiveness is determined by the same procedure that is used in INPUT; that is, the current density levels for all zones of a given type are determined, and for each zone type an accumulation is made. At the end of this step the actual density values by zone type are compared against the ideal values and an error is computed as a ratio. Percentage realization, then, is 1.0 minus that error ratio, multiplied by 100. At this point, two options are appropriate in utilizing the data computed in determining the density contribution.

The measure of effectiveness is an expression which considers a set of five BETA coefficients, wherein the density coefficients are denoted as BETA-2,1; BETA-2,2, and BETA-2,3. Then BETA-2,1 corresponds with the ideal value for *central* zone density; BETA-2,2, with *secondary* density and BETA-2,3 with *remote* zone density.

In this manner, each of the ideal density values for the three zone types are considered separately throughout the run. They contribute to the overall measure of effectiveness by a distribution among the three types, such that an ideal value for density level may be more critical in some zone types than in others.

56 Within MEFF2, the first step in determining the utilization contribution is to eliminate all activities whose corresponding utilization value in array U(I) is less than or equal to zero. Secondly, it is necessary to determine those activities for which the utilization value is twice greater than ideal. Greater than twice ideal would represent greater than 100% error and would have no meaning. For all activities whose utilization is greater than zero, and which have not obtained twice the ideal value, an accumulation is made of both the actual value of utilization and the ideal value of utilization. The actual value is accumulated as an absolute value of UIDEAL minus UACTUAL. The ratio of actual utilization to ideal utilization comprises the utilization error. To obtain a measure of realization toward ideal utilization for all activities, the error is subtracted from 1.

The measure of effectiveness is then computed as BETA1 times the proximity contribution, plus BETA2 times the density contribution, plus BETA3 times the utilization contribution.

APPENDIX 4. PROGRAM DIAGNOSTICS

PROGRAM PURPOSE

MAIN ERROR – NO RESPONSE AVAILABLE FOR INDEX – an incorrect set of cycle numbers and criticality codes have been indicated on a project.

INPUT ***ERROR IN INPUT DATA SEQUENCE. .LIMITS CARD***

ERROR IN INPUT DATA SEQUENCE. .FUNDS CARD

ERROR IN INPUT DATA SEQUENCE. .DENSITY CARD

ERROR IN INPUT DATA SEQUENCE. .SPACE CARD

ERROR IN INPUT DATA SEQUENCE. .DISTANCE CARD

ERROR IN INPUT DATA SEQUENCE. . DELIMITER ENCOUNTERED PREMATURELY INTERZONE DISTANCES

ERROR IN INPUT DATA SEQUENCE. .AFFINITY CARD

ERROR IN INPUT DATA SEQUENCE. . DELIMITER ENCOUNTERED PREMATURELY INTERACTIVITY AFFINITIES

ERROR IN INPUT DATA SEQUENCE. .NO DELIMITER AFTER AFFINITIES

ERROR IN INPUT DATA SEQUENCE. .RULES CARD

ERROR IN INPUT DATA SEQUENCE. . DELIMITER ENCOUNTERED PREMATURELY PROJECTION RULES

ERROR IN INPUT DATA SEQUENCE. . DELIMITER ENCOUNTERED PREMATURELY COSTS

ERROR IN INPUT DATA SEQUENCE. .COSTS CARD

ERROR IN INPUT DATA SEQUENCE. .NO DELIMITER AFTER DISTANCES

ERROR IN INPUT DATA SEQUENCE. .CENTRALIZATION CARD REQUIRED

ERROR IN INPUT DATA SEQUENCE. . CENTRAL ZONES NOT DEFINED, SECONDARY, ZONES NOT DEFINED, REMOTE ZONES NOT DEFINED

ERROR IN INPUT DATA SEQUENCE. . ERROR IN INDIVIDUAL ZONE DEFINITION CARD CHECK ALL

ERROR IN INPUT DATA SEQUENCE. .MISSING UTILIZATION CARD

ERROR IN INPUT DATA SEQUENCE. . DELIMITER ENCOUNTERED PREMATURELY ACTIVITY BASE DATA

ERROR IN INPUT DATA SEQUENCE. .DELIMITER REQUIRED ACTIVITY BASE DATA

ERROR IN INPUT DATA SEQUENCE. . DELIMITER REQUIRED AFTER PROJECTION RULES

ERROR IN INPUT DATA SEQUENCE. . DELIMITER REQUIRED AFTER COSTS

All of the above messages for input data sequence are followed by the following message:

RUN TERMINATED. . . .REVISE DATA SEQUENCE

ACTION: Check input data to insure that the appropriate number of data cards for each data set are available and delimiter cards follow each data set. See data sequence Appendix 1.